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SMALL PLANTS FOR PASTEURIZING MILK

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CONTENTS

	Page
Introduction	1
The building lot	2
Location	2
Size and shape	2
Construction	2
Number of stories	2
Utilization of floor space	3
Materials	3
Floors	4
Wall and ceiling finish	5
Sewerage, water, and ventilation	6
Mechanical equipment	6
Refrigeration	6
Boilers	7
Power	8
Arrangement of rooms	10
Pasteurizing and bottling rooms	10
Receiving room	10
Milk-storage room	11
Bottle-washing room	12
By-products and storage rooms	12
Boiler room	13
Equipment	13
Receiving, can washing, and testing	13
Pasteurizing and cooling	14
Bottle washing and filling	16
Floor plans	17
A plant of 100 gallons daily capacity	17
A plant of 250 gallons daily capacity	18
A plant of 500 gallons daily capacity	19
A plant of 800 gallons daily capacity	21

INTRODUCTION

There are large numbers of small milk dealers throughout the United States who handle only raw milk, or pasteurize only a part of their product. With the increasing demand for pasteurized milk, the dealer marketing raw milk is often faced with the alternative of pasteurizing his supply or going out of business. As a result, there is a genuine need in the market-milk industry for more definite information on the construction and equipment of small pasteurizing plants. This is evidenced by the numerous inquiries received by the Bureau of Dairy Industry from raw-milk dealers who wish to know the requirements for a small plant to pasteurize milk. Others who have small pasteurizing plants wish suggestions for increasing the capacity of their plants.

The results of studies of the construction, equipment, and arrangement of more than 125 small pasteurizing plants are presented in this circular, with an analysis of the findings, and recommendations on the placing, building, and equipment of small pasteurizing plants.

All but six of the plants studied had a daily capacity of less than 1,000 gallons of milk. In tabulating the data, these six plants, which had capacities ranging from 1,000 to 2,000 gallons daily, are included in a few instances, but they were for the most part omitted from consideration.

[1] The writers acknowledge the helpful assistance given by K. E. Parks, Associate Dairy Engineer, Bureau of Dairy Industry, in giving technical advice on the engineering phases of this circular.

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THE BUILDING LOT

LOCATION

The tendency in building small milk plants is to locate them on side streets and on the rear of lots. This is often due to the fact that owners, to economize on first costs, put plants on their house lots, on some other site they already own, or remodel old buildings into milk plants. Though this practice is often the cheapest as regards first cost, it would be well before building to consider the possibilities of a location on a well-traveled thoroughfare. Increased returns through counter sales and the greater advertising value of a well-located plant easily may more than make up the difference in first cost of the plant site.

SIZE AND SHAPE

The size of the lot depends on the size of the plant to be built, the shape of the lot, and the location. Access to the plant by wagons or trucks is essential. An inside lot will require a right of way to the plant and parking and turning space alongside the plant. This extra space is often unnecessary where the lot has one or more sides fronting on streets or alleys. Rectangular lots provide more usable space than triangular or irregular lots of the same area. The plants of larger capacity, of course, require more ground space than plants of smaller capacity.

Table 1 shows the average ground space covered by 96 plants of various sizes. This space includes the boiler room, refrigeration-machinery room, and milk-storage room, but does not include garage or stable room. This ground space must not be confused with the floor space in the plant, which depends on the number of floors as well as the ground area.

TABLE 1.—*Average ground space of 96 pasteurizing plants in three groups*

Plants grouped by quantity of milk handled daily	Plants	Quantity of milk handled daily per plant		Range of ground space	Average ground space	
		Average	Range		Per plant	Per 100 gallons of milk
	Number	*Gallons*	*Gallons*	*Square feet*	*Square feet*	*Square feet*
200 gallons or less	36	133	68– 200	364–1, 632	790	656
201 to 500 gallons	36	331	225– 500	582–2, 034	1, 132	353
501 to 2,000 gallons	24	908	600–1, 800	1, 320–5, 798	2, 450	284

The location selected should have available an abundant supply of pure water and means of sewage disposal.

CONSTRUCTION

NUMBER OF STORIES

The most common type of building for small milk plants is the 1-story building. The next most popular type is the 1-story and mezzanine, or balcony plant. Both the 1-story and the 1-story and mezzanine types permit economy of labor and time in handling milk.

The mezzanine type makes it possible to use gravity flow of the pasteurized milk and thus eliminates at least one pumping, with the accompanying machinery and piping. This type of building is adaptable to plants of all sizes, though it is seldom used for plants of less than 200 gallons daily capacity. The mezzanine gives the advantage of extra floor space without increasing the ground space or man and labor requirements.

In a study of the types of buildings at 107 milk plants it was found that of the 75 plants handling less than 500 gallons daily, 92 per cent were 1-story plants and 8 per cent had mezzanine floors. Of the 32 plants ranging from 500 to 2,000 gallons in capacity, 72 per cent were 1-story and 28 per cent had mezzanines.

UTILIZATION OF FLOOR SPACE

As a general rule, the larger plants use their floor space more effectively than do the smaller ones. In a survey of 96 plants of different sizes it was found that 36 plants handling 200 or less gallons of milk daily had from 243 to 2,031 square feet of floor space per 100 gallons of milk handled daily, or an average of 659 square feet; 36 plants handling from 200 to 500 gallons daily had from 175 to 509 square feet of floor space per 100 gallons, or an average of 370 square feet; 24 plants handling from 500 to 2,000 gallons daily had from 124 to 685 square feet of floor space per hundred gallons, or an average of 298 square feet. In other words, the average floor space per hundred gallons of milk decreases as the total quantity increases.

However, the large amount of floor space per 100 gallons handled in the smaller plants does not necessarily mean that future plants of the same capacity should be made smaller, as most of the plants are built to take care of increases in volume of business. The factor of machinery also enters into consideration; for example, practically all small plants require double storage space for their empty bottles, that is, space for storage before and after washing.

MATERIALS

Any of the ordinary building materials may be used in constructing milk plants. The main precaution to observe is that the inside of a milk plant must be waterproof and easily kept clean. The choice of material will depend largely upon prices and the supply at hand, varying with the different sections of the country and local building regulations.

In a recent study of 110 small milk plants in New Jersey and Pennsylvania, the materials, in order of their use, were concrete block, wood, brick, hollow tile, poured concrete, and stone. Table 2 shows the total number of these plants which were constructed of the various materials listed, with similar data for each size group of plants. In the group of smallest plants, handling 200 gallons of less, frame and concrete-block plants were equal in number. Many of the concrete-block plants were found in the country and small towns, and comparatively few of the frame plants were found in the larger towns and cities. These two materials represented 90 per cent of the plants in this group. Of the plants handling from 201 to 500 gallons daily, 71.1 per cent were made of the heavier materials, and 28.9 per cent were made of wood. In this group were found more elaborate

construction and an increased use of brick and hollow tile with a corresponding decrease in frame construction. In the group of largest plants, 42.9 per cent were of concrete block, 39.3 per cent were of brick, and 10.7 per cent were of frame construction.

TABLE 2.—*Construction materials used in 110 small pasteurizing plants*

Quantity of milk handled daily	Plants in group	Frame	Concrete block	Brick	Poured concrete	Hollow tile	Stone
	Number	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*
200 gallons or less	44	20	20	0	2	1	1
201 to 500 gallons	38	11	15	8	1	3	0
501 to 1,000 gallons	28	3	12	11	0	2	0
Total	110	34	47	19	3	6	1

FLOORS

The floor construction is very important in building a milk plant. The floor must be hard-surfaced to resist wear; it must be waterproof, smooth and easily cleaned, and well drained.

In small plants concrete floors are generally used. A concrete floor meets all the requirements and is comparatively inexpensive. It should have a coved base against all vertical walls to facilitate cleaning. One objection to concrete is that the lactic acid of the milk will pit the cement. In those parts of the plant where there will be extra heavy wear on the floor, as from rolling cans, trucks, etc., over it, iron grids should be placed in the concrete with the tops flush with the top of the floor. Floors with iron and steel chips incorporated in the concrete to resist wear are seldom satisfactory in milk plants, as the chips rust out and leave the floor pitted. Solid iron plates are often used instead of grids, but they are harder to anchor to the concrete and consequently become loose and collect milk and dirt under them, causing foul odors and insanitary conditions.

Vitreous tile, when properly laid, is a very satisfactory floor. The tile surface is harder than cement and will withstand wear better; also, it is comparatively acid-proof. The usual objection to tile floors is that the tiles become loose and the joints eat or chip out. These conditions can be prevented if the tile is set in cement and joints are pointed with asphalt. These asphalt joints will need to be replaced every two or three years.

Terrazzo and wood floors are not so satisfactory as concrete and tile. Terrazzo floors in the workrooms of milk plants are soon pitted by lactic acid and hard wear. Wood floors absorb moisture and wear out rapidly.

Good drainage is essential. The floor should slope not less than one-eighth of an inch per foot. Usually one central drain outlet per room will serve the purpose. A very large room or one where exceptionally large volumes of water are handled may have a gutter, with several outlets, which extends the length of the room and is covered by a grating; or the room may have several drain outlets located near the points of greatest water discharge. All outlets must be trapped to prevent sewer gas from entering the plant.

WALL AND CEILING FINISH

Table 3 shows the wall finishes used in 110 plants visited. Cement plaster was most commonly used. It was found in 41.8 per cent of all the plants and was used in 58.6 per cent of the plants of the 501 to 1,000 gallons group. The next most common wall surface was to use the inside surface of the concrete block or the brick which formed the walls. This surface was in most cases painted or whitewashed, but in many plants it was left unfinished. In the group of smallest plants, 26.8 per cent had this type of wall, and the same number had wooden walls. Although surfaces of walls of common brick and concrete block are fairly satisfactory, they are usually rougher than is desirable even when they are painted. Composition wall board was used in 4.6 per cent of the plants as against 3.6 per cent using gypsum wall board. This, however, does not mean that composition wall board is more satisfactory, as in many of the plants it had warped and pulled loose from the nails.

TABLE 3.—*Wall finishes used in 110 milk plants*

Quantity of milk handled daily	Plants in group	Cement plaster	Inside surface of concrete block or brick	Wood	Composition wall board	Gypsum wall board	Enameled brick or tile	Metal
	Number	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*
200 gallons or less	41	9	11	11	4	4	0	2
201 to 500 gallons	40	20	8	10	1	0	1	0
501 to 1,000 gallons	29	17	8	3	0	0	1	0
Total	110	46	27	24	5	4	2	2

Wall and ceiling finish in the workrooms must be moisture-proof and washable. A perfectly smooth finish with rounded corners is preferable from a sanitary standpoint. Ordinary wall paints seldom withstand for any length of time the constant and hard washing necessary to keep them clean. There are some special paints on the market, however, which stand up under hard scrubbing much longer than others. Some plant managers have obtained very good results by using special water and heat resistant varnishes. Where finances permit, the wall surface may be made of enamel brick or of tile. These make very good wall surfaces but are generally too expensive for small plants. Prepared hard plaster is unsatisfactory for either walls or ceiling where there is much moisture. Where this type of finish is desired cement plaster should be used rather than ordinary plaster. Where the wall construction is of concrete blocks a fairly satisfactory surface may be obtained by applying cement directly to the surface of the blocks.

Some of the commercial gypsum wall boards give acceptable service if kept well painted. It is advisable to paint a wall as soon as the boards are put on and before it is exposed to moisture.

Wood walls and ceilings are very common in small plants. They are quite satisfactory if they are so built that there are no cracks for dirt to lodge in and if they are kept well painted. Concrete, extending 6 to 8 or more inches above the floor level, will facilitate the cleaning operations, make the plant more sanitary, and protect the wood walls from water and consequent rotting.

Metal walls and ceilings have a tendency to rust and become insanitary. Many health departments discourage the use of either metal walls or ceilings.

In Table 4 are shown the ceiling finishes of the plants mentioned in Table 3. Wood ceilings were by far the most common, making up 55.5 per cent of the total. The wood ceilings were mostly tongue-and-groove boards, which were generally painted or in some cases varnished, or both painted and varnished. In general, the comments that apply to wall finishes apply also to ceilings. Ceilings of reinforced concrete were found mainly in the larger buildings and were installed with the idea of later adding another story to the present building or of using the roof for some other purpose necessitating extra strength.

TABLE 4.—*Ceiling finishes in 110 milk plants*

Quantity of milk handled daily	Plants in group	Wood	Cement plaster	Metal	Composition wall board	Gypsum wall board	Reinforced concrete
	Number	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*
200 gallons or less	41	22	4	4	6	5	0
201 to 500 gallons	40	23	10	3	2	1	1
501 to 1,000 gallons	29	16	7	2	0	1	3
Total	110	61	21	9	8	7	4

SEWERAGE, WATER, AND VENTILATION

An efficient sewer system is essential. Where city sewerage is not available, cesspools or septic tanks may be used. The local health authorities should be consulted before any sewer system is installed.

Large amounts of pure water are required for milk-plant operation. Where water is expensive it often pays to drill a well and install pumping equipment, but for the small plant that can buy enough water at a reasonable rate this is an unnecessary expense.

There are many systems for saving water which may be used to advantage, often even by the smaller plants. For example, the regenerative system [2] of cooling milk is one, or the water in pasteurizing and cooling may be used again for washing or as feed water for the boiler.

A good ventilation system will greatly improve the working conditions of a milk plant. Either natural ventilation by the use of skylights or vents through the ceiling and roof, or a fan, or both may be used.

MECHANICAL EQUIPMENT

REFRIGERATION

The different types of refrigeration equipment used at 85 of the plants are shown in Table 5. It will be seen that many of the smallest plants use ice. For the small plant ice refrigeration is often cheaper than mechanical refrigeration, but on the the other hand the latter has advantages that may offset its increased cost.

[2] CLEMENT, C. E., and GRANT, F. M. EQUIPMENT FOR CITY MILK PLANTS. U. S. Dept. Agr. Circ. 99, 1929.

TABLE 5.—*Refrigeration equipment used at 85 plants*

Quantity of milk handled daily	Plants using mechanical refrigeration							Plants using ice					
	Plants using machines of rated capacity						Self-contained air-cooled machines (rated capacity not known)	Plants	Average size of plants	Quantity of ice used—			
										Per day		Per day per 100 gallons of milk handled	
	Plants	Average size of plants	Average rated capacity of machines	Variation in size of machines	Most common size of machine	Rated capacity of machines per 100 gallons milk handled				Average	Variation	Average	Variation
	No.	*Gals.*	*Tons*	*Tons*	*Tons*	*Tons*	*No.*	*No.*	*Gals.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*
150 gallons or less	6	103	2.4	1–4	3	2.6	5	14	111	560	300–900	516	222–900
151 to 299 gallons	20	229	3.5	1–10	1.5, 4	1.5	1	1	200	1,200		600	
300 to 499 gallons	12	350	5.7	2–10	4, 8	1.6	0	2	340	1,950	1,800–2,100	553	450–656
500 to 1,000 gallons	24	715	7.8	3–15	10	1.2	0	0					
Total	62						6	17					

Of 25 plants handling 150 gallons and less per day, 5 used small self-contained, air-cooled compressors. These machines, which have been developed in recent years, seemed to give very satisfactory results where only a small amount of refrigeration was needed. In some cases two compressors were used, one for the milk-storage room and one for the cooler. Their rated capacity was not known.

In that part of the table showing the larger machines, the columns giving the average rated capacity and the most common size of machine are the most important. The column showing the rated capacity per 100 gallons of milk handled indicates that it is customary to use overcapacity machines for the smaller plants, but these figures should not be used as a basis for judging the size of machine to be purchased.

BOILERS

Boilers of proper capacity are just as essential in small plants as in large plants. A boiler that is too small is, in the end, less economical than one that is too large. Even though an undersized boiler will produce enough steam to do the required work, it will use enough extra time and labor to more than equal the extra cost of the larger boiler. Aside from the extra cost of time and labor, a forced boiler wears out more quickly; pasteurization, cleaning, and steaming are apt to be rushed; and the temperature of the water used will often be below that necessary for thorough work.

Each boiler purchased should be of sufficient size not only to supply economically the present needs, but also to take care of any increase in production for the next few years.

Proper insulation with material 1½ inches thick will save approximately 85 per cent of the heat that would otherwise be lost by radiation. This is an economy that should be practiced whenever a boiler is installed.

Table 6 shows data collected at 92 plants of various sizes. The plants are grouped according to the number of gallons of milk handled

daily. For each group is shown the average horsepower of the boilers used by that group and the variation in size of the boilers used.

TABLE 6.—*Sizes of boilers used in 92 plants*

Quantity of milk handled daily	Plants	Average quantity of milk handled daily per plant	Average size of boilers [1]	Variation in size of boilers [1]
	Number	*Gallons*	*Horse-power*	*Horse-power*
150 gallons or less	25	106	8.6	4–20
151 to 299 gallons	25	224	11.8	4–20
300 to 499 gallons	21	397	18.9	8–40
500 to 1,000 gallons	21	782	37.8	15–80
Total	92	359	18.5	4–80

[1] Rated horsepower, not actual.

The type of boiler to use will be somewhat limited by the size. As the size increases there is more choice in type. Boilers requiring a brick setting and brick fire box are seldom used by small plants. Where bricked-in boilers are used the brickwork should be erected only by men skilled in building boiler settings, as the efficiency of the boiler depends to a large extent upon a well-constructed setting.

Table 7 gives the types of boilers used in 99 different milk plants, and the number of plants in each group, using the various types of boilers listed. As all these plants are comparatively small, the vertical boilers predominate; boilers of the self-inclosed type, such as Scotch marine, etc., are next in number; and boilers of the horizontal return tubular type are used least.

TABLE 7.—*Types of boilers used in 99 plants*

Quantity of milk handled daily	Plants	Number of plants using indicated type of boiler		
		Vertical	Self-inclosed	Horizontal return tubular
	Number	*Number*	*Number*	*Number*
150 gallons or less	28	28	0	0
151 to 299 gallons	27	23	4	0
300 to 499 gallons	22	14	7	1
500 to 1,000 gallons	22	9	8	5
Total	99	74	19	6

POWER

The use of electricity to supply power for small milk plants has increased greatly in recent years on account of the reduction in price, both of electricity and motors, and because of the reliability of the supply. Previously steam engines, driving a line shaft, were used almost exclusively. In choosing the type of power to use, it is essential that an adequate supply be available at all times. In certain localities it is still necessary for plants to supply their own power, and in any locality it may be more economical to use power from the plant boilers.

In a study of 101 small milk plants, 98 were found to use electricity for power, 1 used a gasoline engine, and 2 used steam. The plant which used a gasoline engine to drive a line shaft handled less than 150 gallons of milk daily. Of the 2 plants which used steam engines to drive line shafts, 1 was in the group handling less than 150 gallons daily and the other was in the group handling from 150 to 300 gallons daily. Of the 98 plants using electricity 61 used individual motors for each piece of equipment, while 37 used a motor-driven line shaft. (Table 8.)

TABLE 8.—*Number of plants using different applications of electric power*

Quantity of milk handled daily	Plants in group	Plants using—	
		Motor-driven line shaft	Individual motors
	Number	*Number*	*Number*
150 gallons or less	26	11	15
151 to 299 gallons	27	16	11
300 to 499 gallons	16	4	12
500 to 1,000 gallons	29	6	23
Total	98	37	61

The cost of electricity by the month, and by the month per 100 gallons of milk handled daily, as reported at 70 of these plants, is shown in Table 9. The plants are divided too unequally between those equipped with shafts and those with individual motors to give very trustworthy comparisons as to the relative costs of the two methods. The figures do indicate, however, that the use of a shaft driven by one motor is more economical in the smaller plants than is the use of several individual motors. On the other hand, the larger plants can more economically use the individual motors. One disadvantage of the use of the line shaft is that if the one motor fails the whole operation of the plant is stopped, whereas with individual motors only one machine would be affected..

TABLE 9.—*Costs of electricity at 70 milk plants using a line shaft or individual motors*

Quantity of milk handled daily	Plants in each group	Line shaft				Individual motors			
		Plants	Average quantity of milk handled daily	Average monthly cost of electricity		Plants	Average quantity of milk handled daily	Average monthly cost of electricity	
				Per plant	Per 100 gallons of milk handled daily			Per plant	Per 100 gallons of milk handled daily
	Number	*Number*	*Gallons*	*Dollars*	*Dollars*	*Number*	*Gallons*	*Dollars*	*Dollars*
150 gallons or less	17	9	114	5.42	4.23	8	92	7.69	8.12
151 to 299 gallons	20	13	216	37.42	17.10	7	245	46.07	18.97
300 to 499 gallons	9	2	350	17.50	5.42	7	364	49.29	13.63
500 to 1,000 gallons	24	4	531	69.67	13.28	20	740	70.51	9.34

ARRANGEMENT OF ROOMS

The efficiency of any manufacturing or processing plant depends largely upon the arrangement of the rooms and equipment. This applies equally to pasteurizing plants. The milk should pass through the plant as directly as possible. By careful planning, the overhead and the labor of small milk plants may be considerably reduced. Usually the best method of procedure is to select the type and size of equipment required, plan the most convenient and efficient arrangement of this equipment, and then plan the walls and partitions around the equipment as placed.

The plant should be cut up as little as possible by partitions and rooms, but separate rooms for certain equipment are always necessary. The boiler room must be separate from the rest of the plant, and it should never connect directly with the pasteurizing or the bottling room, although it may have a door into the bottle-washing room. A sanitary flush toilet should be included in each plant. This should be in an outside room and should not open into any milk or bottle-handling room.

PASTEURIZING AND BOTTLING ROOMS

The pasteurizing and bottling rooms should be on the outside to insure plenty of light and air, but preferably they should have no doors entering them directly from the outside. These rooms may well be on the street side of the building, for, when well kept, they are always a good advertisement. (Figs. 1, 2,[3] and 3.)

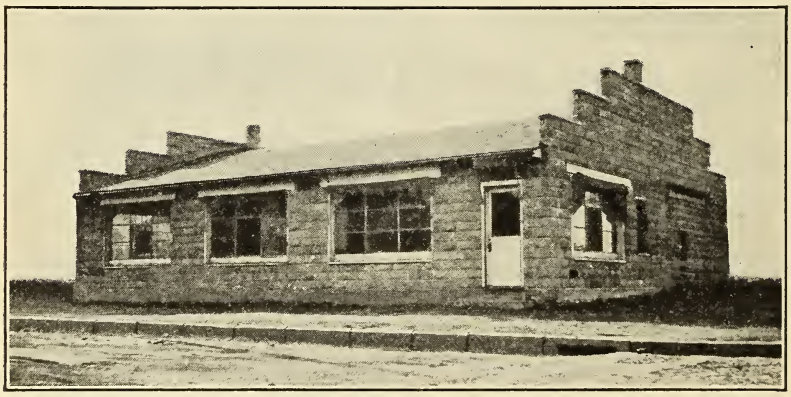

FIGURE 1.—A small milk plant with large front windows through which the plant operations may be seen from the street

RECEIVING ROOM

The milk may be received either in part of the bottle-washing room, by-products room, or, preferably, in a separate room. In receiving the milk there is always a certain amount of dirt carried into the building and many flies are admitted, so the receiving should never be done in the pasteurizing room. State and municipal laws vary on this point, and local regulations should be studied before the final plans are made.

[3] Photographs for figures 2, 4, 5, and 6 by courtesy of the New Jersey State Department of Health.

MILK-STORAGE ROOM

The milk-storage room must be convenient both to the bottling room and to the loading-out door. In order to conserve refrigeration, the smaller the area of wall exposed to outdoor temperatures the better. In most cases at least one wall of this room will have to be

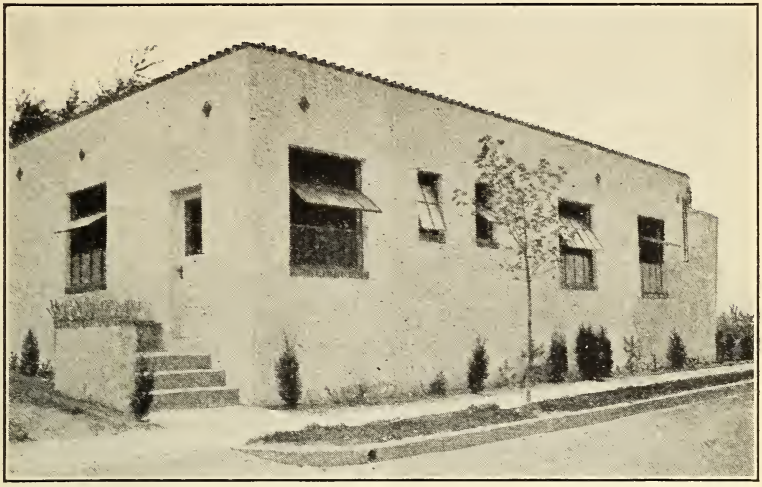

FIGURE 2.—A small milk plant of attractive outside appearance but with windows too high to permit the operations to be seen from the street

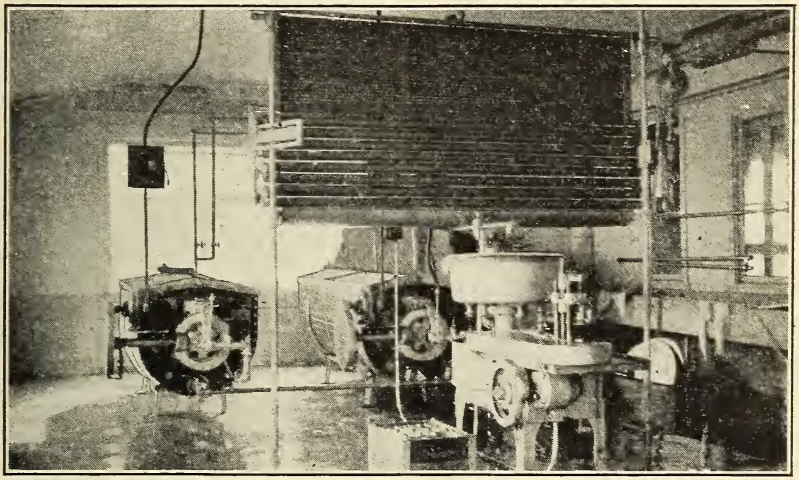

FIGURE 3.—Interior of pasteurizing and bottling rooms of plant shown in Figure 1. Two large windows the same size as the one shown, are in the left wall of this room, facing the street

an outside wall, but the other three should be within the plant. The location of the milk-storage room, however, should not be allowed to impair the efficiency of the plant arrangement, for loss of refrigeration due to outside walls may be overcome by added insulation.

Of the many insulating materials used, sheet cork is the most popular at present. Although 4 inches of cork are often used, 6

inches is better, and more is seldom necessary. Whatever insulating material is used, it should be placed in each of the side walls, the ceiling, and also in the floor.

To facilitate trucking and rolling of cans into the milk-storage room the surface of the floor should be on the same level as that of the adjoining room. All doors, chutes, etc., opening into the milk-storage room should be air-tight when closed. Drains should have water-sealed traps, and openings around pipes and electric wires should be sealed to prevent the entrance of warm outside air.

The floor surface must be strong, smooth, and waterproof to protect the insulation under it and to withstand the hard usage to which it will be subjected.

Where the roof of the milk-storage room is very close to the building roof, added insulation of the ceiling will be needed. The ceiling and the inside of the walls should be coated with a smooth, hard, waterproof finish.

Care must be used in planning the size of the milk-storage room. There must be enough space to take care of the present needs and some expansion, but on the other hand unused space wastes refrigeration. The most convenient height for stacking full bottle cases is six tiers for quart-bottle cases and seven tiers for pint-bottle cases. Any extra height of room over that necessary to handle this number of cases is of no use, except where a brine tank or cooling coils are placed on the ceiling. The inside dimensions of cold-storage rooms at 105 plants are given in Table 10.

TABLE 10.—*Inside dimensions of cold-storage rooms*

Quantity of milk handled daily	Plants	Average quantity of milk handled daily	Average floor space	Height		
				Most common	Average	Range
	Number	*Gallons*	*Square feet*	*Feet*	*Feet*	*Feet*
150 gallons or less	33	106	79.6	7–8	7.5	5–10
151 to 300 gallons	32	232	130.2	7–8	8.8	7–16
301 to 600 gallons	19	434	192.9	8	8.6	8–10
601 to 1,000 gallons	21	785	322.7	8	8.9	8–11
All plants	105	340	164.1	8	8.3	5–16

BOTTLE-WASHING ROOM

The bottle-washing room needs plenty of light and ventilation and must be accessible to a street, alley, or driveway so that the returning empty bottles may be handled expeditiously. There must be space enough so that the room will not be blocked by cases of dirty bottles and yet not so much room that these cases must be moved unnecessarily long distances to the washer.

BY-PRODUCTS AND STORAGE ROOM

In plants of the size here considered a small by-products room is all that is required. This room may, however, be made larger and the extra space used for storage. Except in the smallest plants, some storage space must be provided, if not in a part of the by-products room then somewhere else, where the things stored may be kept clean.

BOILER ROOM

The size of the boiler room will depend largely on the type and size of boiler. Space should not be wasted, but at the same time there should be ample working room. Fuel storage must be provided near the boiler room. At present coal is the usual fuel. If the fuel bin is large enough to hold a carload in the larger plants, or six months' to a year's supply in the smaller plants, savings in the price of the coal can usually be effected.

EQUIPMENT

The various kinds of milk-plant equipment,[4] other than pasteurizers, used in the 108 plants and the number of plants using the different types of equipment are given in Table 11. It will be noted that as the size of the plant increases the equipment used changes from one type to another.

TABLE 11.—*Various kinds of equipment, other than pasteurizers, used in 108 pasteurizing plants*

Quantity of milk handled daily	Plants	Average quantity of milk handled daily	Number of plants using the designated equipment										
				Cooler		Filler		Can washing			Bottle washing		
			Filter	Internal tubular	Surface	Hand operated	Rotary motor driven	Hand	Jet	Machine	Turbine or motor-driven brush	Soaker	Pressure
	No.	*Gals.*											
150 gallons and less	32	105	15	2	30	23	9	24	8	0	19	0	13
151 to 300 gallons	37	234	20	1	36	7	30	22	13	2	15	0	22
301 to 600 gallons	19	447	12	3	16	1	18	8	7	4	5	2	12
601 to 1,000 gallons	20	796	15	0	20	0	20	4	5	11	1	4	15
All plants	108	337	62	6	102	31	77	58	33	17	40	6	62

RECEIVING, CAN WASHING, AND TESTING

Many of the smaller plants use a very simple and inexpensive dump tank for receiving milk, holding about 10 gallons. The outlet is a sanitary fitting with no valve. To this fitting is attached a length of sanitary pipe extending from the tank in the receiving room to the pasteurizer. With this system it is customary to place the pasteurizer next to the receiving-room wall. A hole slightly larger in diameter than the sanitary pipe is cut through the wall at a point just above the top of the pasteurizer. On the receiving room side of the wall are placed brackets, or a shelf, to support the dump tank. The milk is poured into the dump tank and flows directly to the pasteurizer. With this system the milk is weighed in the cans. In the larger plants a weigh can and possibly a receiving vat are needed.

Cans may be washed either by hand, by a single jet with valves for cold water, hot water, and steam, or by a can-washing machine. The machines may be had in various styles and sizes to fit individual requirements or preferences. Some bottle washers are also built to wash cans.

[4] For detailed lists of equipment with approximate costs, see the following publication: CLEMENT, C. E., and GRANT, F. M., Op. cit., pp. 33-36.

Every milk plant should have some method of making simple tests of its milk, either by doing the testing at the plant or sending samples to a dairy laboratory. Many small plants find it more satisfactory to send the samples to a laboratory rather than to test them at the plant.

PASTEURIZING AND COOLING

Most of the small pasteurizers on the market are suitable for small milk plants. (Figs. 4, 5, and 6.) Vats require more floor space than tanks of equal capacity. The main features to take into consideration in selecting a pasteurizer are simplicity and ease of cleaning. In 108 small plants, 46 used tanks and 62 used vats. Of the plants handling less than 150 gallons of milk daily 18 used tanks and 14 used vats. The tanks were largely of the starter-can type. Of the plants handling from 150 to 300 gallons daily 12 used tanks and 25 used vats.

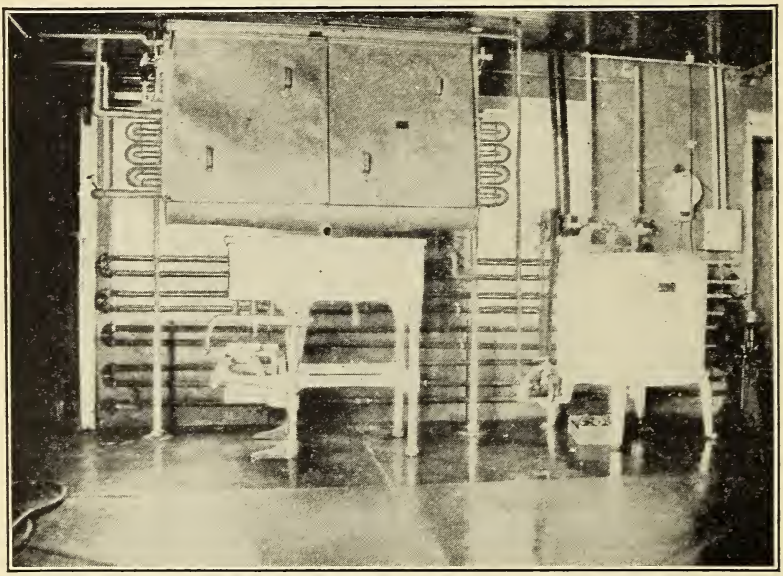

FIGURE 4.—A starter-can type pasteurizer (right) and a single-end hand-operated bottle filler (left) in a milk plant of 100 gallons daily capacity

Of the plants handling from 300 to 600 gallons daily 8 used tanks and 11 used vats. Of the plants handling from 600 to 1,000 gallons daily 8 used tanks and 12 used vats.

Ninety-nine of the 108 plants heated the milk in the tanks or vats and the other 9 used preheaters. Of the 9 plants using preheaters 1 was in the group handling from 300 to 600 gallons of milk daily, and held the milk in tanks. The other 8 plants were in the group handling from 600 to 1,000 gallons daily; and 3 of them held the milk in tanks and 5 held it in vats. The number of pasteurizers used in the same plants, the most common size of vat or tank, and the average total tank or vat capacity per plant, are given in Table 12. In the group of smallest plants some used two pasteurizers, but the number was very small as compared with those using only one pasteurizer. The proportion of plants using more than one pasteurizer increased rapidly, however, with an increase in size of plant.

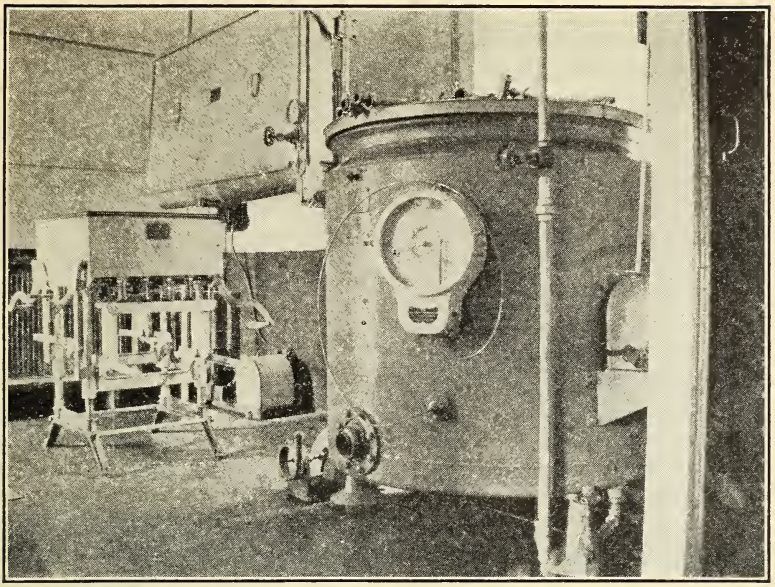

FIGURE 5.—A tank pasteurizer (right) and a double-end hand-operated bottle filler (left) in a milk plant of 150 gallons daily capacity

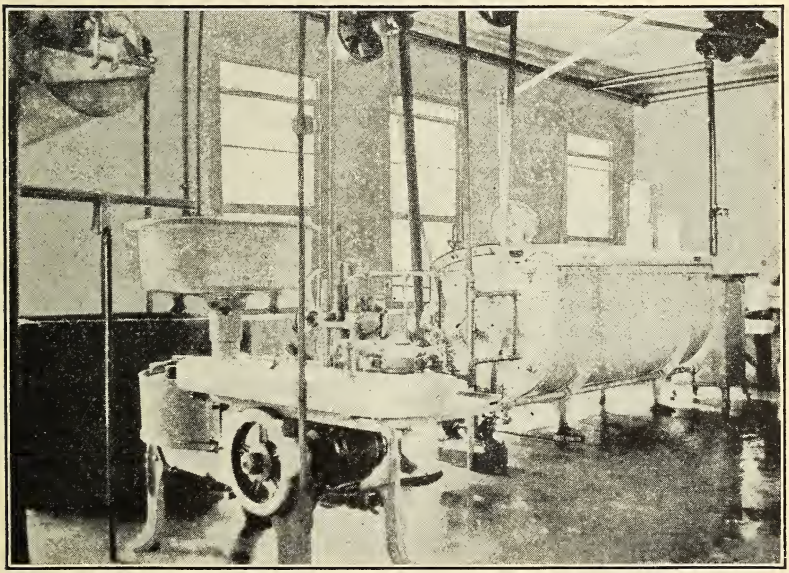

FIGURE 6.—A vat pasteurizer (right) and a small motor-driven rotary bottle filler (left) in a milk plant of 800 gallons daily capacity

TABLE 12.—*Number and size of tank or vat pasteurizers used in 108 plants*

Quantity of milk handled daily	Number of plants in group	Average quantity of milk handled daily	Plants using—								Average total tank or vat capacity
			1 pasteurizer		2 pasteurizers		3 pasteurizers		4 pasteurizers		
			Number	Most common size	Number	Most common size	Number	Most common size	Number	Most common size	
		Galls.		*Galls.*		*Galls.*		*Galls.*		*Galls.*	*Galls.*
150 gallons or less	32	105	29	100	3	100	0	0	0	0	160
151 to 300 gallons	37	234	33	300	4	200	0	0	0	0	250
301 to 600 gallons	19	447	11	300	8	300	0	0	0	0	356
601 to 1,000 gallons	20	796	3	300	12	300	3	200	2	200	520

The milk cooler may be of either the internal tubular type or the surface type. The surface type is more popular with dairymen having small plants. At 102 of the 108 plants the surface cooler was used. (Table 11.) Whichever type of cooler is used, it should be in two sections, well or city water being used for the cooling medium in the first section, with which the milk comes in contact, and ice water, brine, or direct expansion, in the second section.

The pump used to pump the pasteurized milk over the cooler should not be used to pump raw milk into the pasteurizer, as there is always danger that it will not be thoroughly cleaned and treated to kill bacteria, with the result that the whole batch of pasteurized milk will be contaminated. The extra cost of an additional pump is well worth while.

BOTTLE WASHING AND FILLING

At many of the smaller plants, the turbine-driven or motor-driven brush for washing bottles is still in use, but except for the smallest plants (Table 11) the tendency is in favor of machine washing. Even the smallest of the mechanical bottle washers will thoroughly clean the bottles if they are run properly. Plants with a daily capacity of 500 gallons and more can often advantageously use the smaller sizes of the soaker washers. Washers of the pressure or "in-the-case" type, which handle bottles in cases, are made in sizes to suit plants of any size.

Although the hand-operated bottle filler is satisfactory for the smaller plants, power-driven fillers are becoming more popular and are practically a necessity in a well-run plant handling any appreciable volume of milk.

The methods used in 73 plants for transferring the cases of filled bottles to the milk-storage room are shown in Table 13. Usually the same system is also used in handling the cases from the milk-storage room to the delivery equipment.

TABLE 13.—*Method of transferring cases of filled bottles to milk-storage rooms used at 73 pasteurizing plants*

Quantity of milk handled daily	Plants in group	Plants in each group using designated system						
		Carried by hand	Dragged by hooks	Trucks				Roller conveyor
				Platform	Dolly	Lift	Total	
	Number	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*
150 gallons or less	20	13	0	3	4	0	7	0
151 to 300 gallons	22	9	2	4	7	0	11	0
301 to 600 gallons	16	2	0	4	4	1	9	5
601 to 1,000 gallons	15	1	0	5	2	1	8	6
Total	73	25	2	16	17	2	35	11

FLOOR PLANS

The following plans worked out by the Bureau of Dairy Industry [5] are offered as suggestions and guides for designing the arrangement of small milk plants of various sizes. An effort has been made to have the plants large enough to allow plenty of working room and access to all sides of the equipment for cleaning purposes, and at the same time to eliminate any waste space.

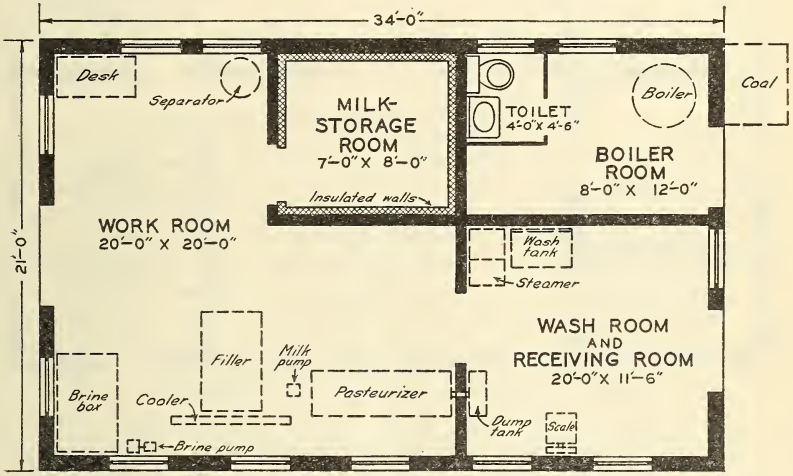

FIGURE 7.—Plan for a milk plant of 100 gallons daily capacity

A PLANT OF 100 GALLONS DAILY CAPACITY

Figure 7 shows the floor plan for a plant to pasteurize and bottle 100 gallons of milk a day. A plant of this size should be as simple as possible in construction and arrangement. Ice is used as the cooling medium, with a brine box for the cooler and an ice bunker in the top of the milk-storage room. Mechanical refrigeration can easily be substituted for ice if desired. As the business grows and more room

[5] Assistance was rendered by the Bureau of Agricultural Engineering, U. S. Department of Agriculture, in the preparation of these plans.

is required, the plant may be enlarged by the construction of a mezzanine over the rear part or over the milk-storage room extended. The pasteurizing and bottling equipment is concentrated in a small space so that one man can conveniently take care of both, the sanitary piping is short, the pasteurizer is close to the dump tank, and there is good light. The entrance to the boiler room is from the outside. This arrangement prevents odors and dirt from the boiler room entering the rest of the plant.

For this plant either dolly or platform trucks may be used. As soon as the cases of bottles are steamed they are loaded on these trucks. When the truck is full it is placed near the bottle filler. After the bottles have cooled, they are filled, replaced in cases and again loaded on the trucks and put into cold storage. Trucks are

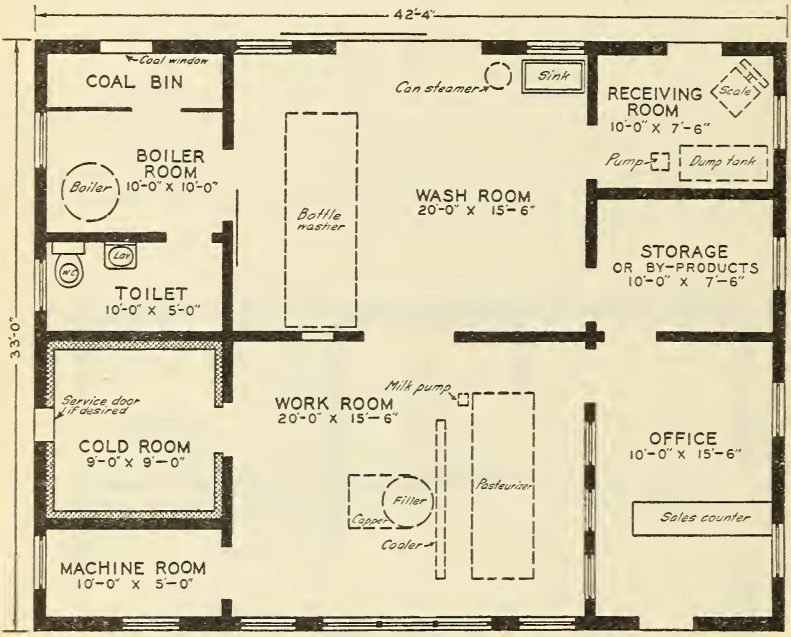

FIGURE 8.—Plan for a milk plant of 250 gallons daily capacity

also used in loading out. By this system one man can move from 6 to 18 cases at a time with great savings of time and labor over the system of carrying each case separately.

A PLANT OF 250 GALLONS DAILY CAPACITY

A floor plan for a conveniently arranged plant with a capacity of 250 gallons daily is shown in Figure 8. This plan calls for a long frontage with large windows facing the street. These windows not only give plenty of light but they also advertise the plant by showing the pasteurizing and bottling processes. The compressor in the front of the building serves to attract attention, especially if it is brightly painted. Also, the compressor room protects one wall of the milk-storage room from outdoor heat in summer.

Loading out may be done either directly through an opening from the milk-storage room to the outside of the plant, or indirectly through the bottling room and wash room to a door at the rear of the plant. With the first system a chute or roller conveyor could be used, whereas the second system would require trucks.

This plant may be enlarged in three ways, depending on local conditions and the preference of the owner. (1) If the size of the lot permits, an addition may be built onto the rear of the plant, and the front rooms increased in size. (2) A full story may be added, making a clerestory over the pasteurizing room, a mezzanine over the wash room, and additional rooms over the present side rooms. This would allow the pasteurizing equipment to be put over the wash room and allow the present side rooms to be reduced in number and increased in size. (3) Elevate that part of the roof over the wash room and present pasteurizing room, and build a mezzanine over the wash room for the pasteurizing equipment. In each case, the bottling equipment would remain in the original location.

The plan calls for a dump tank of 50 to 75 gallons capacity. It is assumed that the milk will be weighed in the cans. A weigh can may be added at a slight additional cost if it is desired.

The pasteurizing, cooling, and bottling equipment when placed as shown will get the best light and also may be seen through the windows. The bottle filler is also convenient to the clean bottles and to the cold-storage room.

The bottle washer shown is one of the small pressure washers, arranged to deliver the cases of bottles directly into the bottling room where they are convenient for filling.

A PLANT OF 500 GALLONS DAILY CAPACITY

The floor plan for a plant to handle 500 gallons of milk daily is shown in Figure 9. This plant may be built with entrances on only two sides if necessary. It has a well-lighted pasteurizing and bottling room. There is also ample light in the by-products room. The bottle-washing room, however, should have a skylight. This skylight will serve not only to admit light but also for ventilating.

The receiving-room floor is about 4 feet above the main floor. This makes the unloading and loading of cans easier and permits a gravity flow from the weigh can to the receiving vat. The receiving vat is placed in one corner of the pasteurizing room. This shortens the length of sanitary pipe needed between the vat and pasteurizer and puts the vat where it can be easily cleaned and where the man in charge of pasteurizing can keep his eye on the quantity of milk in the vat.

The plan indicates two 300-gallon vats, a milk pump, a surface cooler, and a rotary filler and capper.

The filled bottles may be loaded out of the milk-storage room either directly or through the wash room.

The by-products room is large enough so that in most plants part of it may be used for storage of bottle caps and other clean supplies and for laboratory purposes.

By placing the washer as in the plan, the dirty bottles may be stored between the door and the washer or put directly into the washer. This also leaves space for stacking the clean bottles between the washer and the bottling room.

For a plant of this size a horizontal boiler is preferable. With the boiler room situated as shown, it is convenient to the rest of the plant and the length of steam pipe is as short as practicable. This

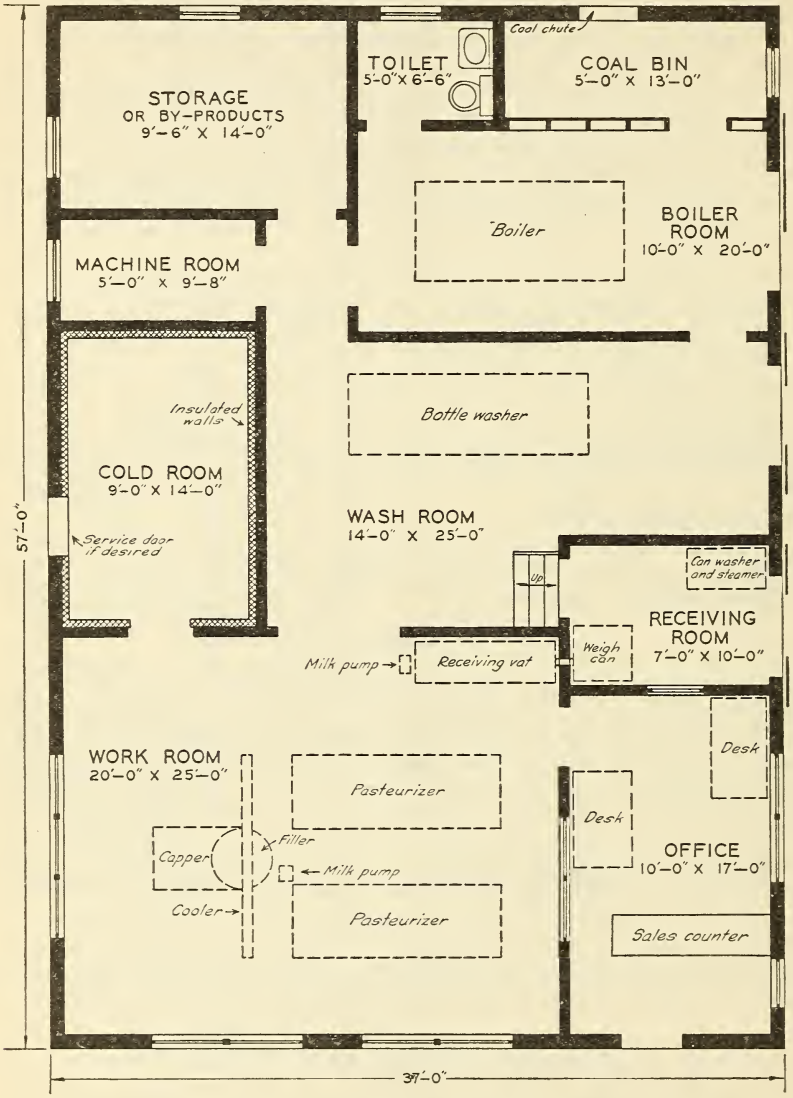

FIGURE 9.—Plan for a milk plant of 500 gallons daily capacity

arrangement also gives a choice of locations for the coal chute either on the end or side of the bin.

A PLANT OF 800 GALLONS DAILY CAPACITY

The floor plan, shown in Figure 10, requires a lot with access to the building, on three sides.

No partition is shown between the receiving room and the by-products room, as the size and location of these rooms, in the space indicated, will depend upon the access to the plant, the system of loading out, and the use to which the by-products room is to be put. These

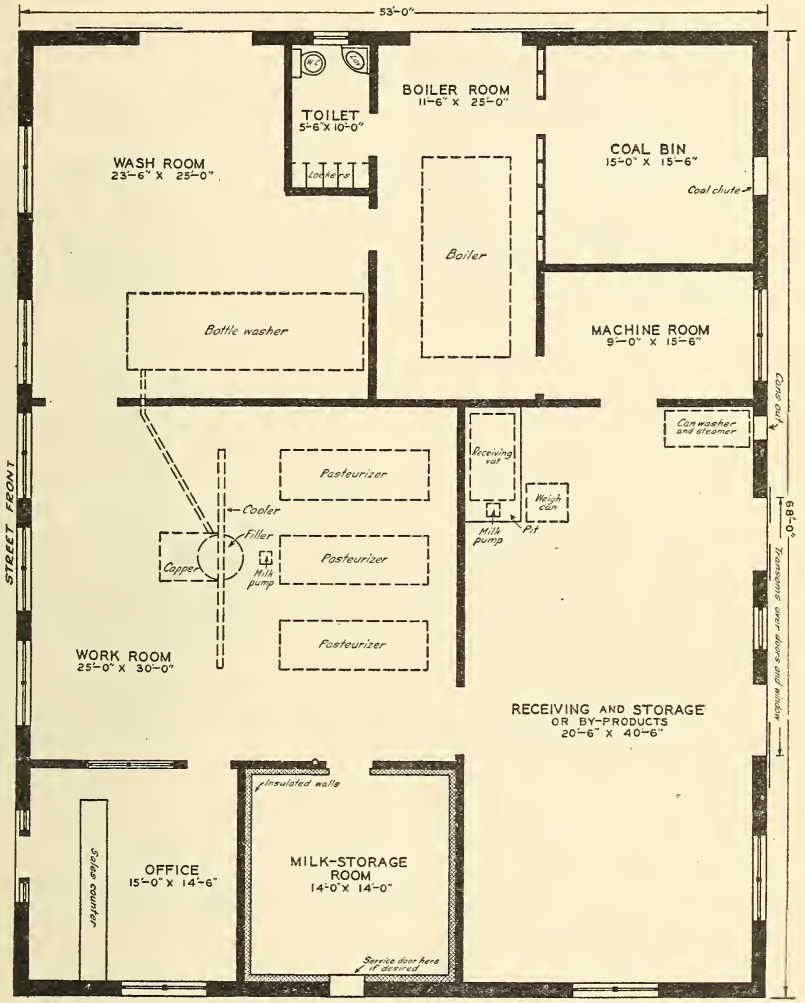

FIGURE 10.—Plan for a milk plant of 800 gallons daily capacity

will vary with each plant, and the partition between the rooms can be placed accordingly.

As shown, the processing room calls for three pasteurizing vats, each having a capacity of 300 gallons, a milk pump, surface cooler, and rotary filler and capper. The clean bottles are delivered directly from the washer to the filler by a bottle conveyor, while the empty

cases are delivered separately on a roller conveyor. The filled and cased bottles would be stacked on trucks for storage and loading out.

In the wash room there is a small soaker type "comeback" bottle washer. As this washer delivers the individual bottles directly to the filler, no storage space for clean bottles is needed. For this reason the washer is placed next to the wall which is between the wash room and the pasteurizing room; thus all of the space between the washer and the outside door is available for the storage of dirty bottles.

The boiler is readily accessible to the rest of the plant and is near all the equipment needing steam for operation.

The coal bin is large enough to hold 40 to 50 tons. If it is not desired to buy coal in these quantities, some of this space may be used for other purposes.

If the receiving vat is placed in a pit, as indicated in the plan, the pit must be large enough to allow workmen access to all sides of the vat to clean the vat and the pit. Also, the pit should be provided with a trapped drain. An alternate construction would be to raise the receiving room as in Figure 9, and place the receiving vat on the main floor level.

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